AMARAVATI
DEEP DIVE WORKSHOP

14, 15 DECEMBER 2017
THE GATEWAY HOTEL, VIJAYAWADA

Liveability | Economic Powerhouse
Infrastructure | Governance

Infrastructure

POWER AND RENEWABLES

December 14, 2017

1. INTRODUCTION:

The Government of Andhra Pradesh proposed to establish `Amaravati', a world class capital city for the State which is situated at location with 16.5830 Latitude & 80.3670 Longitude and falls under the District, Guntur. The aspiration is to create a peoples' capital that is vibrant, diverse, inclusive, and modern which is a glowing pride for all the people of Andhra Pradesh. With the cities around the globe gearing up towards becoming "Smart", it is important to establish a clear frame work that will help to achieve this Vision. Amaravati, the new State Capital of Andhra Pradesh offers an excellent opportunity to realize this target, as it is mostly being built on a greenfield site, with minimal constraints for development. Amaravati will be a Smart City that leverages the foundations of good urban planning, transparent governance, open data and enabling technologies that will ascertain our position as a vibrant, people-centric, connected and economically prosperous city.

Present population of the city comprising of 27 villages is and the expected population of the city by 2050 is 3.55 million. At present, there are 7 Nos, 33/11kV substations with installed capacity of 2x5 MVA serving all 27 villages to meet the requirement of power and the Power is distributed through overhead LT transmission lines.

2. VISION:

- To provide 24 X 7, Uninterrupted quality Power, Reliable with Redundancy facility at every stage to the capital city Amaravati.
- Supervisory Controls and Data acquisition through latest communication technologies is proposed for Automation of Transmission and Distribution of Power.
- Smart Grid with distributed Renewable Energy resources (Solar Power) with Auto Reclosure for zero interruptions.
- Under Ground cabling for Transmission & Distribution of power to avoid bare power line proximity accidents.
- Smart metering of real time energy consumption and computation of on line power losses, to take instant corrective measures by means of Demand side management, to avoid under frequency, to maintain unity power factor and to avoid over loading of some of the circuits.

3. CONCEPT OF TRANSMISSION & DISTRIBUTION SYSTEM

Main components of Smart Power Supply Infrastructure are:

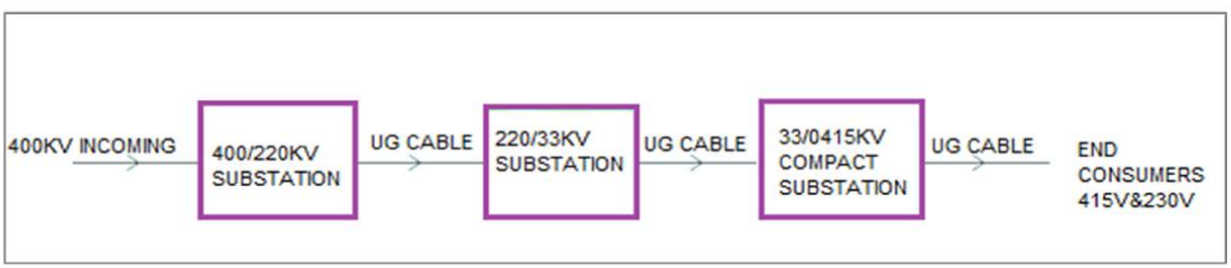
- Transmission & Distribution of power to Amaravati, smart capital city of AP
- 400KV/220KV & 220/33KV Gas Insulated Substations
- 33KV Gas Insulated Switch Gear Distribution centers (33KV Switching Stations).
- Compact Substations
- Smart Grid
- Supervisory Controls and Data Acquisition (SCADA)
- Micro control stations (Micro Grid).
- Transmission of Power through Underground Cables
- Smart Energy efficient street lighting.
- Renewable Solar Energy.
- Smart Net Energy Metering.
- Energy Efficient Street Lighting

3.1 Transmission & Distribution of power to Amaravati

Power is transmitted to all over the city at Extra High Voltage levels to reduce power transmission losses before reaching the consumer. Normally Power Transmission & Distribution is carried out in 5 stages to reach consumers. Available Five stages of Transmission & Distribution are:

1) 400KV/220KV
2) 220KV/132KV,
3) 132KV/33/KV
4) 33KV/11KV,
5) 11KV/415 Volts, before reaching consumer.

In Amaravati, with the approval of "Experts Committee", to reduce costs and system losses, conventional five stages of Transmission from EHV to LV i.e. from 400 KV to 415 volts is reduced to 3 stages i.e. 400/220KV, 220/33KV and 33KV/415V by avoiding 132kV & 11kV levels of transmission.



To ensure reliable, uninterrupted 24X7 quality Power, Smart Grid and Redundancy at every stage of transmission & distribution is proposed with SCADA and decentralized renewable energy generation. Power demand assessed across Amaravati city including Startup Area is 3500 MW.

3.2 400kV/220kV; 220kV/33kV GIS sub stations:

400kV/220kV and 220kV/33kV GIS Substations are proposed for smart Transmission & Distribution of 3500 MW of power for a world class smart city. All EHV/HV/MV i.e. 400KV/220KV;220KV/33KV Sub Stations and 33KV Switching Stations (Distribution centers) for Transmission & Distribution of power across Amaravati city are planned as indoor Sub Stations with Gas Insulated Switchgear (GIS).

3.3 33KV Distribution Centers (Switching Stations):

33kV Distribution centers (Switching Stations) to receive power from 220KV/33KV EHV substation and distribute 24 MVA of power through 10 Nos. of 33KV feeders to feed power to 33KV/415V Compact Substation to meet requirement of power of all types of consumers. All 33KV Distribution centers serve as consumer service centers. Consumption details of all consumers is monitored through remote monitoring and monthly consumption bills are served to consumers through e mails or SMS.

3.4 Compact Sub Stations:

All Distribution Transformers are planned for installation in a container with complete protection & switch gear. In view of the enormous rise in per capita power consumption in the recent years and individual sizes of plots allotted to Farmers under land pooling scheme, the future network requirements are recognized, and hence proposed 33kV / 415V, distribution transformers in the form of Compact Sub Stations to receive power from 33KV Switching Station and also from Renewable and Distributed Energy Resources (DERs) to meet the challenges of the future Smart grid.

3.5 Smart grid:

Represent one of the most significant evolutionary changes in energy management systems to enable decentralized energy systems, the use of large-scale renewable energy as well as major improvements in demand-side-management.

3.6 SCADA (Supervisory Controls and Data Acquisition):

Through applying SCADA information technology to existing electric transmission & distribution networks, smart grids provide opportunities to integrate more decentralized supply systems (e.g. renewable energy) and allow consumers to take more proactive roles in demand-side-management with available real-time data acquired by SCADA components.

3.7 Micro grids:

Micro grid is a localized power grid with 185 Nos, 33kV Distribution centers, that operate in synchrony with the main grid duly integrating Distributed Solar energy sources. RTUs with optic fiber underground cables / wireless mode for remote monitoring and controls of Smart Energy Meters, critical components of MV Transmission & Distribution. Event logging, real time monitoring of performance of Smart Meters to assess theft of energy and on-line assessment of power losses.

3.8 Underground Cabling:

Underground cabling infrastructure for voltage levels of 400KV, 220KV, 33KV & 415V is designed for transmission & distribution of power. Amaravati will be the first smart city in India free from overhead power lines. Environmental Sensors that monitors Fire, condition of air, water, Ventilation system for safety of under- ground cables.

3.9 Renewable Energy - Solar power

Amaravati will have integrated roof-top solar PV panels on all Government buildings, railway and metro stations, schools, hospitals, commercial and residential complexes, thereby making efficient use of space. The decentralized solar energy thus produced would be meshed with smart grids to serve the local communities. Solar energy generation potential on Roof top across Amaravati city is assessed as 1800 MW. It is also proposed to make it mandatory for all private & Government buildings to install PV Panels on Roof top to help to reduce CO_2 emissions of coal based Thermal Power Stations by reducing power demand by means of distributed roof top solar generation.

3.10 Smart Net Energy monitoring:

To measure, calculate and report about power consumption by all types of consumers and energy received from distributed energy resources. Net energy metering is allowed by Government of AP to compute the nonconventional energy generated and energy consumed by him simultaneously by means of Smart Energy Meter so that the Net monthly consumption bill can be raised and served to the consumer.

In addition to the use of open data, we are also proposing new forms of infrastructure technologies across a range of areas including: High Speed Internet services by means of virtual private network / Fiber optic cable to the Home / public wi-fi services for mobile Internet access in public locations to read smart meters with robust IT connectivity and digitalization.

3.11 Energy Efficient Street Lighting

One of the most important civilization indexes is the development of a good transportation network. This includes streets, roads and highways that must be adequately illuminated so that a sufficient visibility is guaranteed to decrease the accident rate and increase the flow of the vehicles and safety.

Energy-Efficient lighting systems that consist of one or more components listed below:

- Low loss ballasts
- Better monitoring and control mechanisms
- LED Lights

4. OBJECTIVES OF THE PROJECT

- Real time Energy monitoring and Energy Audit
- Reducing Power losses (AT&C) to most minimum level.
- Un interrupted 24x7 reliable Power supply with Redundancy at all levels up to end consumer.
- Underground cabling for transmission & Distribution of Power
- Smart Energy Metering Infrastructure
- Distributed Renewable Solar Energy
- Distribution Automation

4.1 Real Time Energy Monitoring and Energy Audit:

Energy Audit is made statutory to all bulk consumers and for all Utilities licensed for distributing energy to all types of consumers. Integration of SCADA with Smart Grid is proposed to facilitate computation of real time energy consumed and supplied simultaneously at all levels right from 400KV SS, 220KV SS, 33KV Switching station & 33KV/415V Compact SS and finally at the consumer level.

With this arrangement, energy losses in Transmission and Distribution can be computed at every stage at any point of time. Corrective action can be initiated to attend to the issues causing power losses.

4.2 Reduction in Power Losses

Each unit of Energy saved is 1.2 times more than the Energy generated. Locating the substations at load centres to reduce length of cables, choosing energy efficient Transformers, selecting correct size of cables with less resistance, avoiding over loading of Distribution Transformers and UG Cables, are considered while designing power transmission and distribution system with a view to reduce power losses.

4.3 Uninterrupted 24x7 Power supply with Redundancy:

Any 220kV/33kV substation proposed in the capital region can be fed from any one of the three 400kV substations proposed in the capital region with the help of proposed Ring at 220kV level for Redundancy. In case of failure of 33kV Incoming supply to all Distribution centers under a 220kV/33kV substation due to problems on 220kV side or on 220/33kV Power Transformer, 33kV bus of that 220/33kV substation, shall be fed by 33kV interconnecting cable feeders emanating from 2 no's adjacent 220/33kV substations, 100% of the load of the substation under break down shall be shared equally by each adjacent 220/33kV. Even in case of sharing the load of adjacent 220/33kV substation, adjacent 220/33kV substations will not get over loaded, because the normal load on any 220/33kV Transformer is not more than 65% in normal load conditions.

A 33kV ring is formed connecting all 10 Nos. 33kV Distribution centers under a 220kV/33kV substation to cover all regions under that 220kV/33kV Substation to maintain uninterrupted supply. In case of any fault in the distribution level of any 33kV distribution center, that area will be covered by two adjacent Distribution centers on either side of the Distribution Center under break down. Even in the case of sharing load of Distribution center under breakdown, by adjacent Distribution centers, they will not be over loaded as 35% load margins are available on all individual Distribution centers. Similarly, if any fault occurs at 415 volts, with LT underground cables or with any Distribution Transformer, LT feeders of adjacent Transformers are interlinked with a changeover switch. All Distribution Transformers are loaded maximum up to 60% of its capacity, so that the Distribution transformers will not be over loaded even in case of load covered by the distribution transformer under break down is falling on the adjacent Transformers.

4.4 Underground Cables for Transmission & Distribution of Power:

Safety is considered as utmost priority and hence overhead transmission lines are avoided. UG cables of adequate sizes & rating are proposed to reduce T & D power losses and to enhance the life of cables. 100% power is transmitted through UG cables.

4.5 Distribution Automation

Distribution automation (DA) optimizes a utility's operations and directly improves the reliability of its distribution power system. At present, power utilities have realized the need for full scale distribution automation to achieve on-line system information and remote-control system. This is required to fully accomplish the restricting the establishments of the power system to the level of retail wheeling. On the other hand, the main motivation for accepting the distribution automation is to improve operation efficiency of distribution system. This indicates worldwide interest for distribution automation at present. Looking at the necessity of power Utilities for distribution automation, academic institutions are now taking interest to introduce courses and R& D activities in the field of DA in the regular academic curriculum.

5. POWER DEMAND FORECAST

Power Demand is directly proportional to the built-up area and built-up area depends on number of the habitants in the capital region. Master plan classification of area utilisation is considered. Based on the area of each classification, Built-up area is arrived duly considering ground coverage, net floor coverage & Floor area ratio for all utilities. LED lighting fixtures are considered to minimise the Street lights lighting demand. District cooling system is considered only for Government buildings. Power Demand is assessed across township of the capital region.

Power demand is directly proportional to the built-up area of the structures, purpose of utilization, financial status, and strength of population living in. Indian standards for requirement of power, with the combination of Chinese standards considered are given below.

Classification	Standards Watt/Sq.m	Diversity Factor
Residential (R1-R4)	22-37	0.3-0.5
Commercial (C1-C6)	30-50	0.5-0.6
Industrial (I1-I3)	35,40 & 60	0.4
Government / Institutional (S1-S3)	30-35	0.5
Parks & Open Spaces (P1,P2)	5	0.4
Utilities (U1 & U2)	1.5	0.4

Classification	Power Demand(MW)
Residential	**998.51**
Commercial	667.96
Government / Institutional	234.90
Industrial	553.00
Parks & Open Spaces	32.02
Roads	19.11
Residential area in commercia l & Industrial Zones	46.26
WTP & STP & Solid waste	40
DCS System	40
ICT	26
Line losses (1.78%)	48.24
Grand Total	**2706.0**

6. SOURCE OF POWER TO AMARAVATI CITY

Major source of power to Amaravati city is from AP Genco's Thermal & Hydel power stations, with installed capacity of 7500 MW transmitted through AP Transco EHV transmission line. 9 EHV/HV transmission lines of APTRANSCO & PGCIL are passing through the AP capital region, which are already proposed for diversion

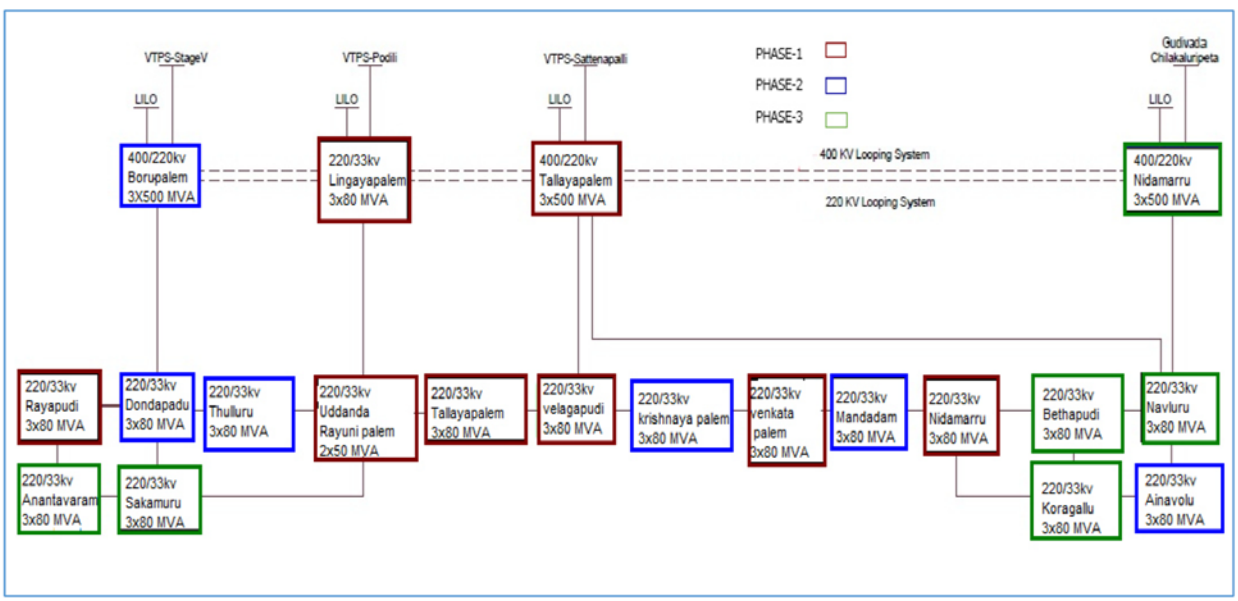
6.1 PROPOSED INSTALLED CAPACITY OF INCOMING EHV SUBSTATIONS

APTRANSCO: APTRANSCO approved 2 Sub-stations which are to be constructed near Krishna Bund at Lingayapalem and Tallayapalem. 1) 220/33KV. 2)400/220KV

Proposed Incoming Substations

1. 220KV/33KV, 3x80 MVA (240MVA) Substation at **LINGAYAPALEM** on 220kV double circuit transmission line from VTPS to PODILI with Line in and Line out arrangement.
2. 400KV/220KV, 3X500MVA (1500MVA) Substation at **TALLYAPALEM** on 400kV double circuit transmission line from VTPS to SATTENAPALLI with Line in and Line out arrangement.
3. 400KV/220KV, 3X500MVA (1500MVA) Substation at **BORUPALEM** on proposed 400kV double circuit transmission line from VTPS- vth stage to SATTENAPALLI with Line in and Line out arrangement.
4. 400KV/220KV, 3X500MVA (1500MVA) Substation at **NIDAMARRU** on proposed 400kV double circuit transmission line from GUDIVADA to CHILAKALURIPET with Line in and Line out arrangement.

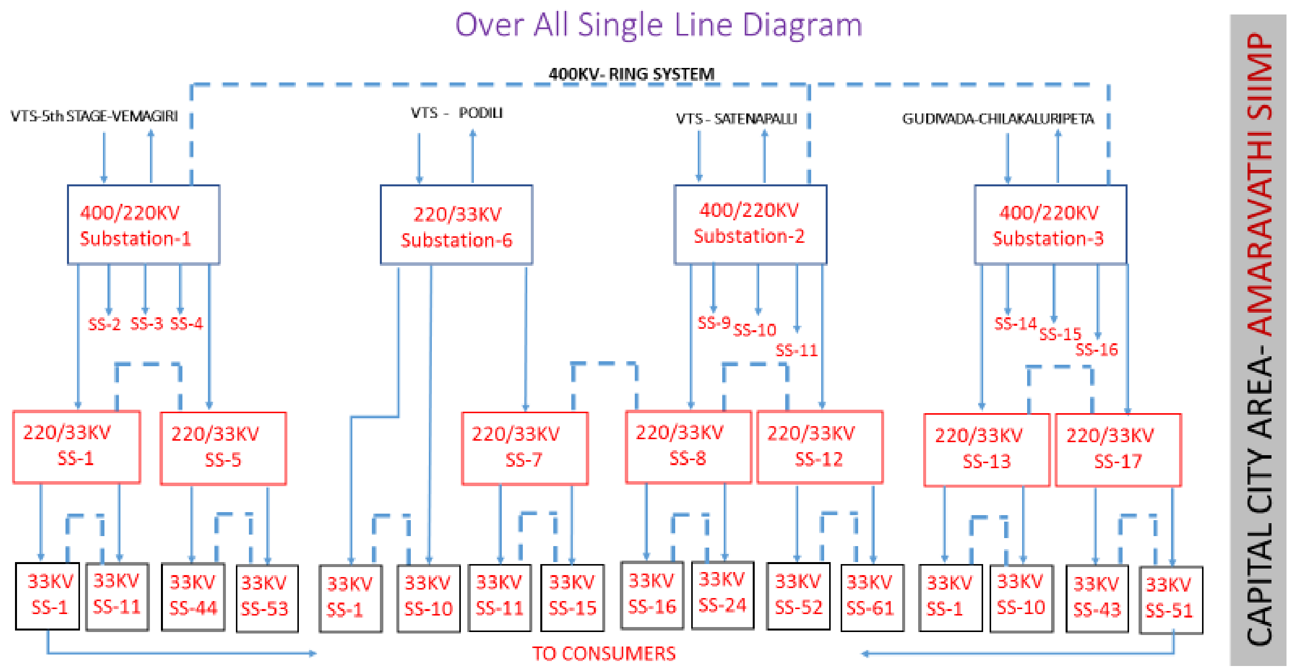
Power Flow Block diagram



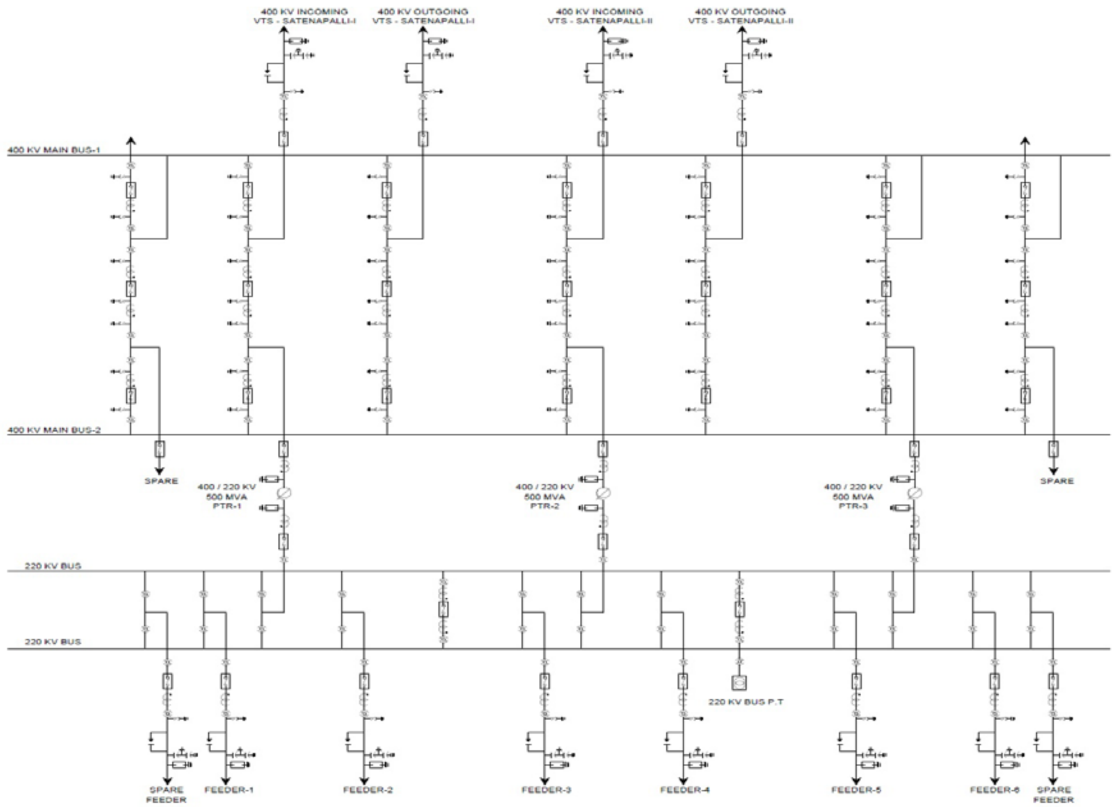
Total installed capacity of all proposed Incoming EHV Substations = 4880 MVA, All the substations will be in operation with 60% of load against installed capacity of the Substation. All 400KV/220KV

Sub Stations are proposed as indoor type with Gas Insulated Switch Gear (GIS). Incoming 400KV is stepped down to 220kV by Power Transformers at proposed 400KV Sub Stations.

Overall single line diagram



Single line diagram for 400kV/220kV Substation

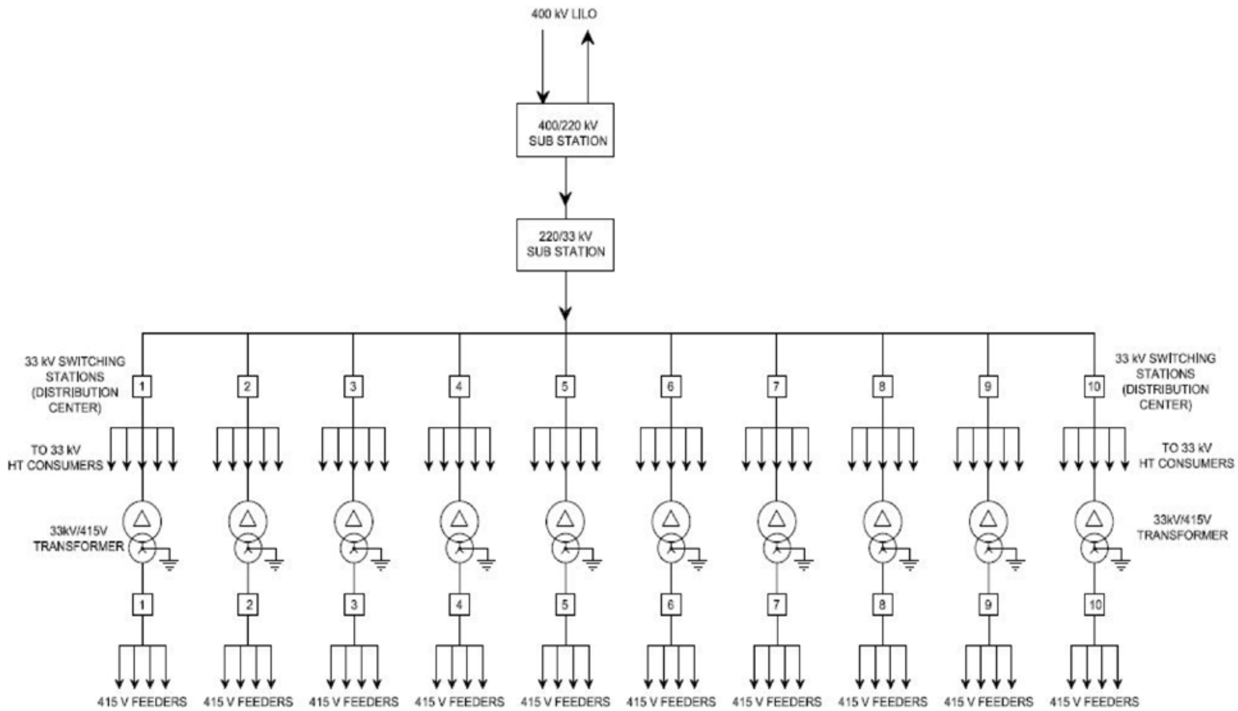


Transmission of Power at 220KV Level:

From 400kV/220kV substations, the power is transmitted at 220kV level to 19 nos. 220kV/33kV substations located all over the city. All 220KV/33KV Sub Stations are proposed as indoor type with Gas Insulated Switch Gear (GIS). SLD for general arrangement scheme of power supply is as shown below.

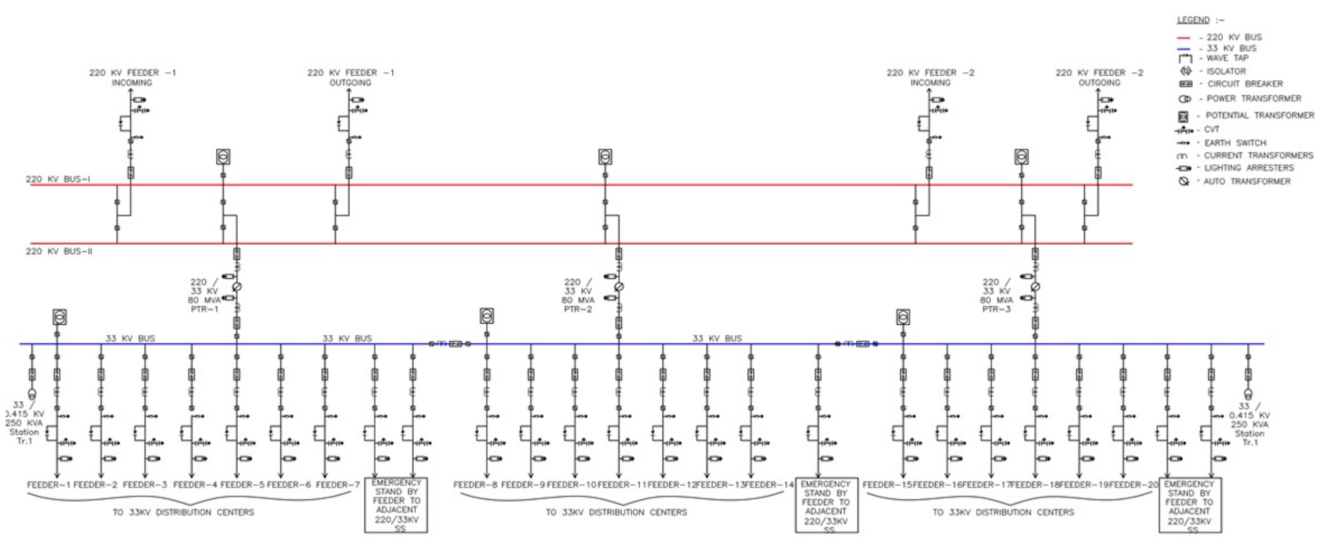
Locations of 220KV/33KV Substations. 16No's: 1) Dondapadu 2) Rayapudi 3) Uddandarayunipalem 4) Velagapudi 5) Tallayapalem 6) Venkatapalem 7) Krishnayyapalem 8) Ainavolu 9) Sakamuru 10) Kuragallu 11) Neerukonda 12) Nidamarru 13) Bethapudi 14) Nowluru 15) Thulluru 16) Anathavaram and other three substations in AGC area.

SCHEMATIC DIAGRAM OF GENERAL ARRANGEMENT OF POWER SUPPLY TO HT & LT CONSUMER

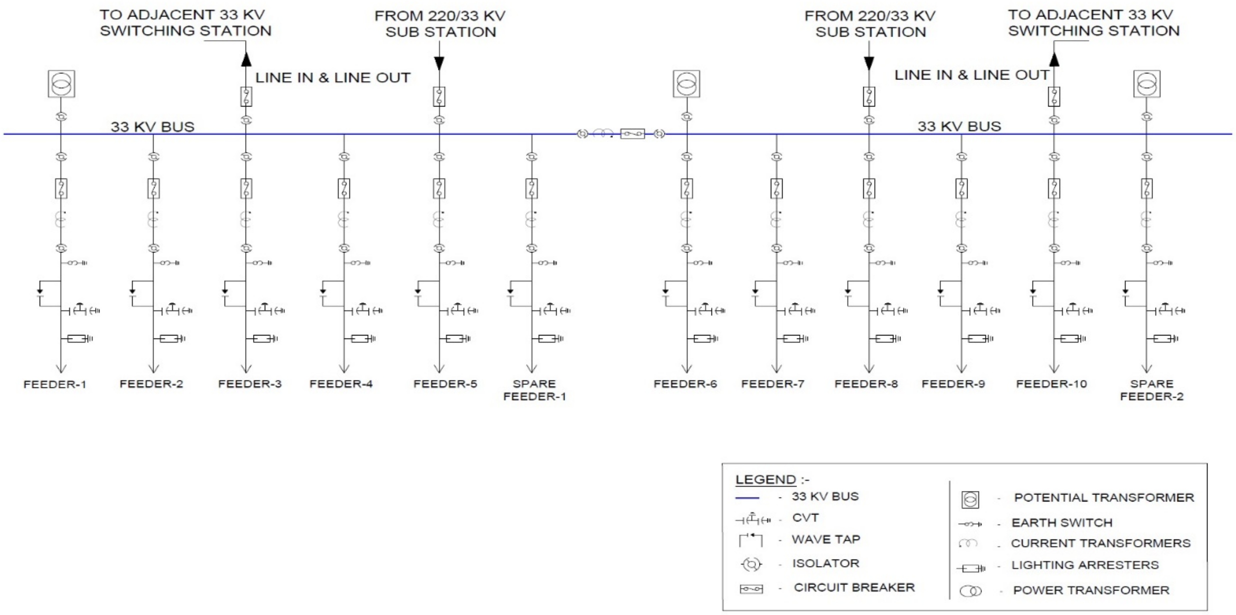


Proposed installed capacity of each 220KV/33KV Substation: 3x80MVA= 240MVA. Total installed capacity of all 220KV/33KV Substations = 16x240 + 720 (Incoming SS) = 4560 MVA i.e. 1.56 times the assessed demand of Amaravati City. Proposed 400KV/220KV, 220KV/33KV Substations & 33KV Switching Indoor GIS Substations are located across the city for distribution of power to the end consumer as shown in the map and SLD.

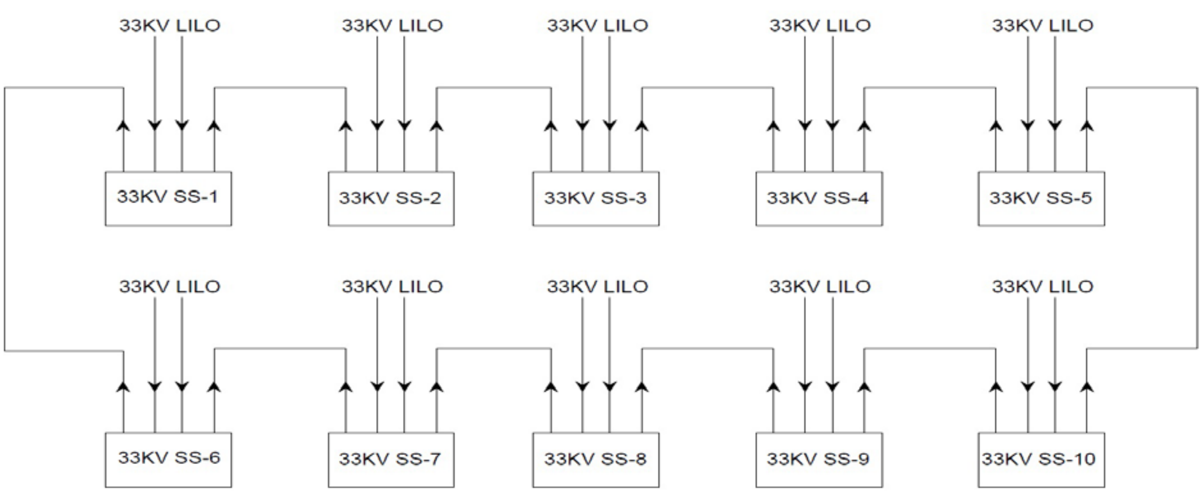
Single line diagram for 220kV/33kV Substation



Single line diagram for 33kV Switching Stations



Schematic diagram for 33kV Switching stations with ring system



NOTE:-
1. LINE IN LINE OUT ARRANGEMENT FOR 33KV INCOMING FEEDERS FROM 220/33KV SOURCE.

<u>**EHV Substations, Switching stations requirements**</u>

Description	Zone-1 Under 440/220KV Borupalem SS	Zone-2 Under 400/220KV Tallayapalem SS	Zone-3 Under 400/220KV Nidamarru SS
Demand(MW)	868	1019	819
Demand(MVA)	913	1073	862
400KV Substations	1	1	1
220KV Substation	19		
33KV Substation	185		

400kV/220kV, 3X500MVA (1500MVA): 3no **(4500 MVA)**
220kV/33kV, 3x80MVA(240MVA): 18nos **(4320 MVA)**
220kV/33kV, 3x80MVA(240MVA): 1no **(240 MVA)**
33kV, 3X8 MVA(24MVA): 185nos **(4440 MVA)**

6.2 ZONES

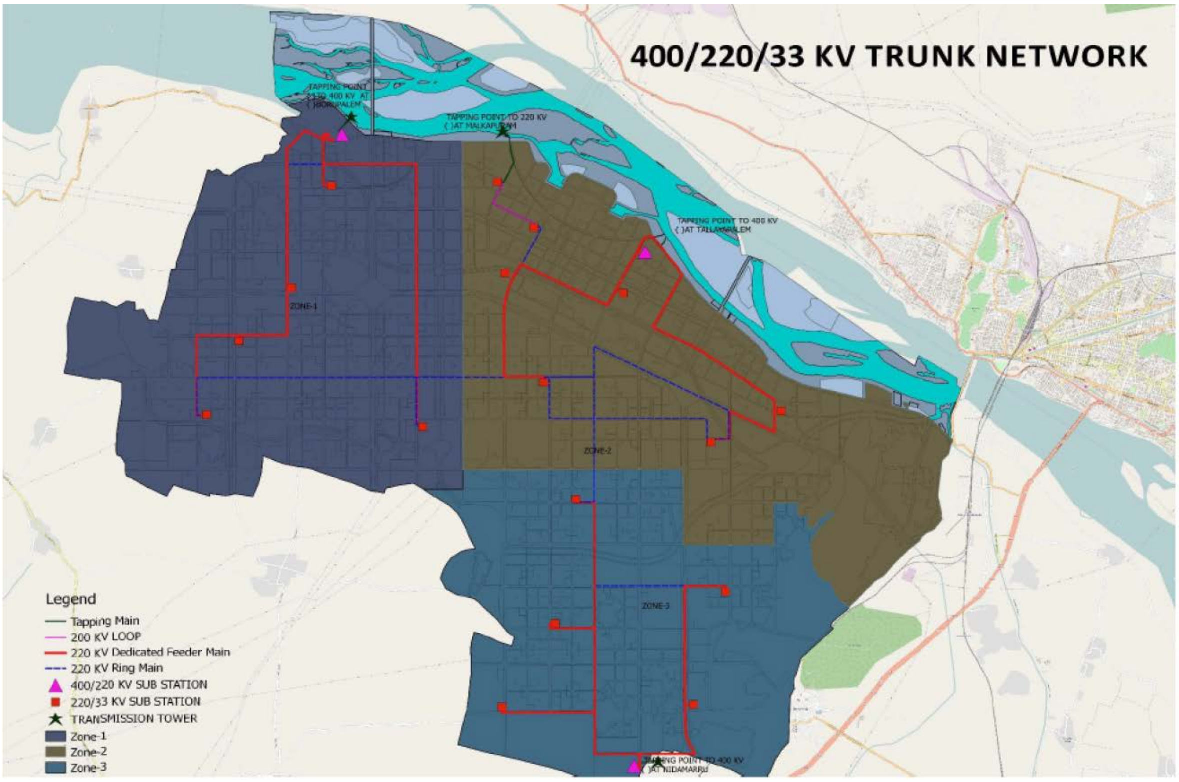
Entire Capitol region is divided into 3 Zones, coming under three 400KV Substations to facilitate the power sharing corresponding to the demand and to keep equal margins on Substation capacities of all Zones.

220KV ring is formed in each Zone and interconnectivity across different Zones is also provided in case of power failures in other Zones. Development is not anticipated Zone wise.

All 220KV Substations are inter linked so that the power supply can be extended to any part of the capitol from any Substation of any Zone

6.3 PHASING

The project work to be implemented in a phased manner based on area priorities allocated for Government Buildings, Educational Institutes, Industries and growth of population. Construction of 400KV Substation, 220kV Substations, and 33kV distribution centers along with required Underground cable trenches to be taken up in a planned way to optimize the cost and to mobilize finances



During development in a phased way, Cable Trench routings to be planned in such a manner to utilize the same duct, even if the source of power supply is changed to a particular area from the in-service Substation to a new substation

Based on Detailed Master Plan Map on the allocation of areas to different categories of utilization of land, the whole area development is divided into three phases. Phase-1: Seed Capital area, parts of Industrial, commercial and Residential areas including integration of all existing villages. Phase-2: Parts of Residential and Industrial areas. Phase-3: Parts of Residential and commercial areas. It is only our assumption. Phasing proposals are not clear in RFP. In view of above considerations, a proposal to construct 400KV & 220KV Substations along with Distribution centers in a phased manner is mentioned below.

Phase-I:
400KV SS at Tallayapalem, 220KV Substations at 1) Lingayapalem. 2)Rayapudi. 3) Uddandarayunipalem. 4) Velagapudi. 5) Tallayapalem.

Phase-II:
400KV SS at Borupalem. 220KV Substations at 1) Krishnayapalem. 2) Ainavolu. 3) Tulluru. 4) Dondapadu. 5) Mandadam 6) Venkatapalem.

Phase-III:
400 KV SS at Nidamarru. 220kV Substations at 1) Ananthavaram. 2) Sakamuru. 3) Navluru. 4) Kuragallu. 5) Bethapudi 6) Nidamarru. If there are some changes in the areas of development, accordingly changes can be effected in the construction program of Substations.

7. POWER LOSSES

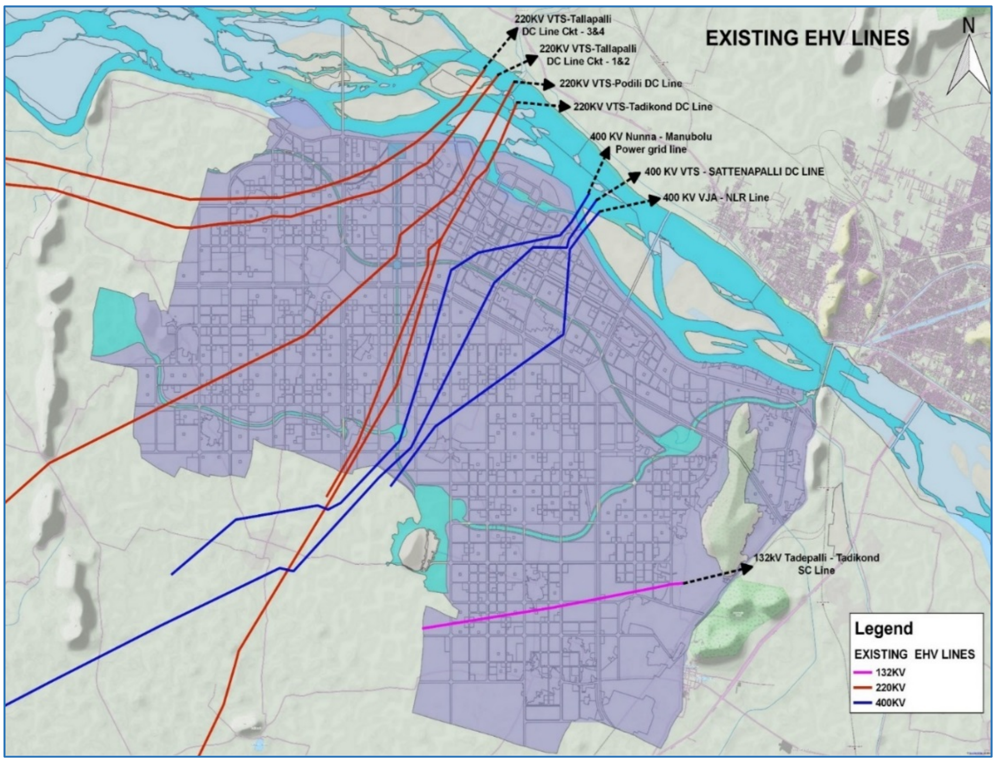
A typical electrical distribution system at Amaravati and projected power losses in Transmission & Distribution at different stages is as follows.

- EHV (220KV) transmission & 400 KV/ 200 KV Transformation:
  Envisaged maximum losses 0.27 % or efficiency of 99 .73%
- Sub-transmission (33KV) & 220KV / 33 KV Transformation:
  Envisaged maximum losses 0.43% or efficiency of 99.57%
- Step-down to a level of 33KV / 415 kV and Distribution:
  Envisaged losses 4.12% or efficiency of 95.88%
- Distribution is final link to end user at 33KV / 415 kV.
- Cascading efficiency of power distributed = 99.73*99.57*95.88 = 95.21%
- Envisaged Total losses: (100 – 95.21) = 4.79%
- 220KV Transmission Losses arrived: 0.6425 MW.
  33 KV Transmission Losses arrived: 4.93 MW.

8. EXISTING EHV LINES AND PROPOSED DIVERSION

As per the existing power policy of Government of Andhra Pradesh, APGENCO, APTRANSCO & APSPDCL are the Stake holders of Generation, Transmission and Distribution of power in the state. APTRANSCO have entered agreements to purchase 10718 MW of power. APTRANSCO, already got the approval for two substations, one at 220 kv level by Line-in & Line-out arrangement of 220KV VTPS-Podili 220kv Transmission line, with installed capacity of 4x80= 320 MVA, and another Substation at 400 KV level with Line-in & Line out arrangement of 400kv, VTPS- Sattenapalli Transmission line, with installed capacity of 3x500= 1500 MVA. Both, VTPS-Podili 220kv Transmission line and 400KV, VTPS- Sattenapalli, Transmission lines are passing through capital region. These EHV Transmission lines are emanating from Vijayawada Thermal Power Station (VTPS) just 5 KMs away from capital region across Krishna river. All EHV Transmission lines are proposed for diversion.

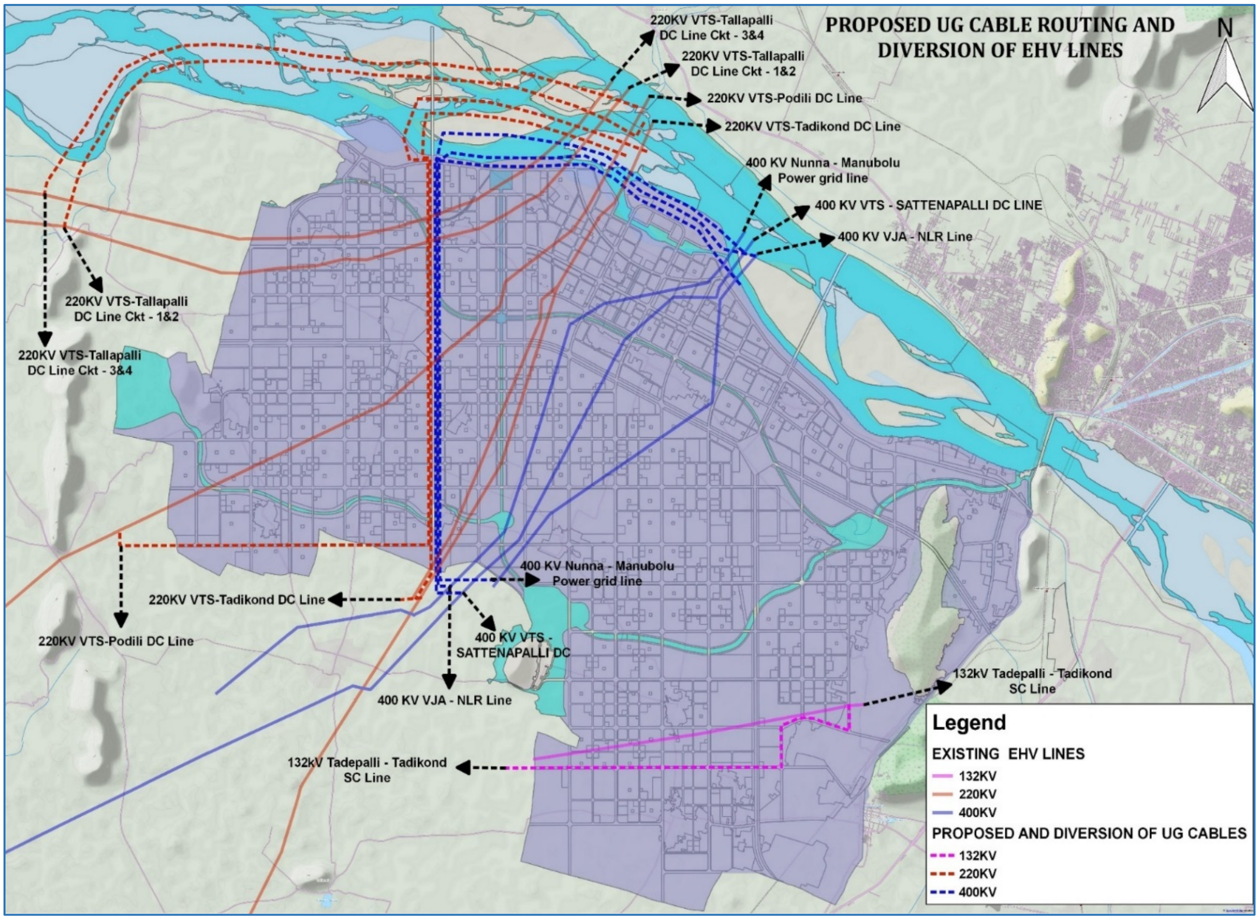
Existing EHV Lines



Diversion of Existing EHV Lines

ROW REQUIRED AT ROAD NO: N13			
AP TRANSCO		PGCIL	
LEFT	RIGHT	LEFT	RIGHT
400KV	220KV	400KV	Nil
8X4m-1no	6X4m-2no	8X4m-1no	Nil

Proposed UG cable rerouting and diversion of EHV Lines



9. INTEGRATION WITH OTHER INFRASTRUCTURE FACILITIES/SERVICES

9.1 WATER:

2 Nos. Raw water pump houses are proposed. 1) At Vykuntapuram. 2) Undavalli along with water treatment plants and clear water pump houses.

Arrangement of power to Vykuntapuram raw water pump house: required power: 3.0MW. Dedicated 33kV feeder from 33kV Switching station will be extended. Arrangement of power to clear water pump house near Borupalem: required power: 12 mva. Dedicated 33kV feeder will be extended to clear water pump house from nearby 220kV/33kV SS.

9.2 DISTRICT COOLING

1 Nos. District cooling Plants are proposed on either side of Government Buildings block. Power required for District cooling system: 16MW for the plant. Shall be provided from nearest 220/33kV SS by means of dedicated feeders.

9.3 SEWERAGE

Power supply at 415v level will be provided to all pumping stations and Intermediate pumping stations through dedicated 33kV/415v compact substations from the nearest 33kV switching stations.

9.4 SOLID WASTE

Transfer stations are located at 3 locations and the power requirement is 2.0 MW for each station. Power requirement for WTE & Bio methanation plant is 2.1 MW for each plant. 33kV dedicated feeders will be provided from 33kV switching stations to each plant.

9.5 ICT

Data from Smart Meters installed to monitor energy consumption at all consumer premises is received through wireless communication by Data centre established at all 165 Switching stations. Same Technology can be utilised for collecting Water and Gas consumption details. Communication and Data Transfer from field to Substations and from substation to substation is done through Fibre Optic Cable. Fibre optic cables can be utilised for other activities of ICT Wing. Location of Base Towers and Receiving Towers for wireless communication and Data Transfer shall be finalised in coordination with ICT Wing.

10. KEY FACTS & FIGURES

10.1 Power Demand

- Power Demand for Capital City – 3500 MW
- Power Demand for LPS Zones – 2049 MW
- Power Demand for AGC – 260 MW

10.2 Phasing of Power Infrastructure

	24x7 Supply	Phase -1 (2017 to 2020)	Phase -2 (2020 to 2030)	Phase-3 (2030 to 2040)	Phase-4 (2040 to 2050)
Total Demand Estimated	3500 MW				
400 Kv SS Nos		1		1	1
220 Kv SS Nos		3	3	6	7
33 Kv Switching Stations Nos		30	50	60	45
33 kV RMUs		240	400	450	390
Compact Secondary Substations - CSS (includes 500 kva, 315 kva and 250 kva) - Estimated		200	500	700	657
Estimated cumulative Power Demand		350	950	1950	2700
Estimated Cost in Rs Cr		2760	4112	4887	1942